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Innermost stable circular orbit near dirty black holes in magnetic field and ultra-high-energy particle collisions

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Abstract

© 2015, The Author(s). We consider the behavior of the innermost stable circular orbit (ISCO) in the magnetic field near “dirty” (surrounded by matter) axially symmetric black holes. The cases of near-extremal, extremal, and nonextremal black holes are analyzed. For nonrotating black holes, in the strong magnetic field ISCO approaches the horizon (when backreaction of the field on the geometry is neglected). Rotation destroys this phenomenon. The angular momentum and radius of ISCO look model-independent in the main approximation. We also study the collisions between two particles that results in the ultra-high energy $$E_{\text {c.m.}}$$Ec.m. in the center-of-mass frame. Two scenarios are considered—when one particle moves on the near-horizon ISCO or when collision occurs on the horizon, one particle having the energy and angular momentum typical of ISCO. If the magnetic field is strong enough and a black hole is slowly rotating, $$E_{\text {c.m.}}$$Ec.m. can become arbitrarily large. The kinematics of the high-energy collision is discussed. As an example, we consider the magnetized Schwarzschild black hole for an arbitrary strength of the field (the Ernst solution). It is shown that backreaction of the magnetic field on the geometry can bound the growth of $$E_{\text {c.m.}}$$Ec.m.

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